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OPEN-FILE REPORT 77-UR

GROUND WATER STUDY FOR THE CITY OF CLEAR LAKE, SOUTH DAKOTA

by

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INTRODUCTION

This report contains the results of a ground water study conducted by the South Dakota Geological Survey from July 21 to August 12, 1982, in and around the city of Clear Lake, Deuel County, South Dakota. The purpose of the study was to assist the city of Clear Lake in locating a dependable source of acceptable quality ground water.

At the time of the study, Clear Lake was obtaining its municipal water from two wells drilled into surficial glacial outwash about half a mile east of the city. There were actually three city wells in the area, but in 1971, a water-softening plant located near City Well 3 suffered a major brine spill (fig. 1). The spill caused high sodium and chloride concentrations in City Well 3, eventually forcing its closure. After the spill occurred, City Well 2 showed no immediate changes in water quality. In 1978, however, water samples from City Well 2 showed more than a tenfold increase in sodium and chloride concentrations as compared to samples from 1971 and 1975 (table 1). City Well 1, which is farther removed from the brine spill than City Well 2, had not shown this sudden deterioration of water quality. However, as seen in table 1, chloride concentrations in City Well 1 have increased since 1972. It appeared that the brine that was migrating through the outwash has affected City Well 2 and may affect City Well 1 in the future.

Although sodium and chloride in low concentrations are not considered to be detrimental to human health and have no recommended limits in public water supplies, their presence can affect the taste and corrosiveness of a water supply. In addition, individuals suffering from heart disease or hypertension are often placed on sodium restricted diets by their physicians.

This investigation then had two main goals: to determine the direction of the brine movement and to locate sites for possible new city wells. This was accomplished through test drilling and water sampling in and around the city of Clear Lake (fig. 2). Twenty-seven test holes were drilled with a mud-rotary rig, and 11 of the test holes were cased with 2-inch diameter polyvinyl chloride (PVC) pipe and sandpoints for use as observation wells. Descriptive logs of all test holes and observation wells can be obtained from the South Dakota Geological Survey in Vermillion. Water samples were collected from seven of the observation wells and from two nearby observation wells maintained by the Water Rights Program. In addition, casing top elevations were surveyed for all of the observation wells and the depth to water was measured so that a water level map could be made.

RESULTS

Ground-Water Movement

Ground water movement is in an easterly direction (fig. 3). City Well 3, the site of the brine spill, is upgradient from City Wells 2 and 1. This indicated that the brine was migrating toward City Wells 2 and 1 from City Well 3.

Extent of Aquifer

The areal extent and saturated thickness of the surface outwash in the Clear Lake area were partially mapped by the South Dakota Geological Survey in 1976 (Barari and Beissel, 1976). The 1976 data have been combined with test hole data from the 1982 investigation to make a more complete map of the saturated thickness (fig. 4). As figure 4 shows, saturated thickness values of greater than 30 feet occur at the southwest corner of the lake and also near the middle of section 24 on the northeast side of the lake. However, if a city well was installed in this zone of maximum thickness, a pipeline at least 1½ miles long would be required to carry water to the city. In an attempt to minimize such costs, 1982 test drilling was concentrated closer to the city.

Test hole 106, drilled 1/3 mile east of the city in 1982, showed the outwash to have a saturated thickness of 15 feet. Because this thickness equals that in City Wells 1 and 2 and because the test hole is close to the city, several other test holes were drilled near it. However, as figure 4 shows, saturated thickness values decrease to 10 feet and less within a few hundred yards to the north, east, and west of the well. The saturated thickness of the area immediately south of test hole 106 could not be determined because corn fields limited drilling access.

Water Quality

Table 2 shows the chemical analyses of water samples collected in the Clear Lake area. Samples B and C were collected from City Well 1 and 2 in December 1981, and the other nine samples were collected from observation wells during August 1982.

The concentrations of manganese and total dissolved solids are the ones that most commonly exceeded the recommended limits. Seven of the samples exceeded the manganese limit and eight exceeded the total dissolved solids limit. Also, the chloride concentrations in samples C and 6 and the iron concentration in sample 9 exceeded the recommended limits (table 2). None of the maximum contaminant levels for fluoride or nitrate were exceeded.

Two samples, C and 6, greatly exceeded the chloride limit and in general are of far worse quality than the other nine samples. These two samples also have very high sodium, hardness, total dissolved solids, and conductivity values. High concentrations in sample C collected from City Well 2 are probably due to the brine contamination. Sample 6 was collected from observation well 110, over half a mile from the brine spill. Looking at figure 2, the sewage disposal pond located 300 yards north of observation well 110 may have been also a contamination source. Further testing would be required to confirm or disprove this, however.

Sample 1, from observation well 106, is of interest because of that area's potential as a new city well site. The water quality of sample 1 is comparable to that of City Well 1, however, the manganese concentration in well 106 may be of concern. The manganese levels vary rapidly in a short distance. Sample 2, collected less than 200 yards west of sample 1, is similar to sample 1 in quality except that its manganese level is only 0.03 ppm. Thus, it is hard to predict what the manganese levels of a city well near observation well 106 would be.

RECOMMENDATIONS

Near observation well 106, the saturated thickness of the surface outwash may be enough to support a city production well. To further determine this possibility, a series of test holes should be drilled in the field south of test holes 106, 113, 121, and 124. These holes should be drilled from 50 yards to a quarter of a mile south of the existing test holes. They should be spaced so as to determine as accurately and completely as possible the saturated thickness in this area. If the new test holes show saturated thicknesses of 10 feet and greater, then the area may possibly support a city production well. However, construction of a test well and running an aquifer test would be needed to determine the potential of this area for a municipal well development. In addition, water samples should be collected to determine manganese values in the area.

Other potential sites for a new city well include test hole 120 where the saturated thickness is 13 feet and test hole 123 where it is 11 feet. These two test holes are both within ½ to 1 mile of the city and could be considered for further investigation if the area near test hole 106 proves unsatisfactory. Another possibility would be further exploration in the zone of maximum saturated thickness near the southwestern part of the lake. The probability of this area having sufficient water is high.

The results of this study were presented on May 3, 1983, at the Clear Lake city council meeting. It was also mentioned that water samples should be periodically collected from the present city wells and analyzed to determine possible further deterioration of the water quality by the brine spill.

POST-INVESTIGATION ACTIVITIES

During the late 1980's, the concentration of sodium, chlorides, and total dissolved solids continued to increase in the City Wells 1 and 2. The city followed the recommendations of the South Dakota Geological Survey and drilled additional wells east of the city. Two city wells were constructed in the area (City Wells 4 and 5). City Wells 1, 2, and 3 were then plugged. Presently the city is utilizing City Wells 4 and 5 for the municipal water supply.

REFERENCES CITED

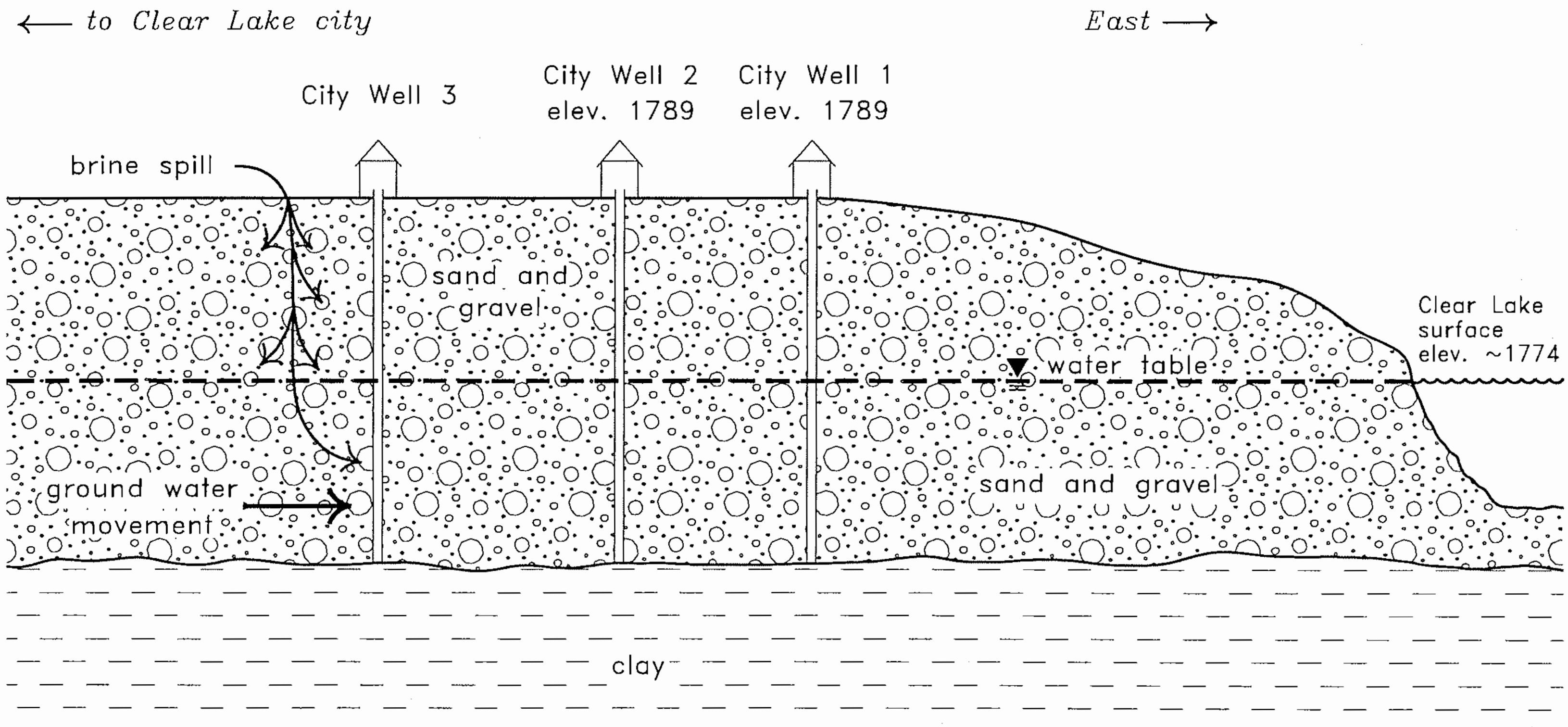
Barari, A., and Beissel, D., 1976, *Ground-water study for the Brookings-Deuel Rural Water System*: South Dakota Geological Survey Open-File Rept. 7-UR.

U.S. Environmental Protection Agency, November 1994, *Drinking water regulations and health advisories*.

Figure 1. Location of the three city wells and brine spill at Clear Lake, South Dakota.

Horizontal scale = 1 inch = 1/16 mile = 330 feet

Vertical scale = 1 inch = approximately 15 feet



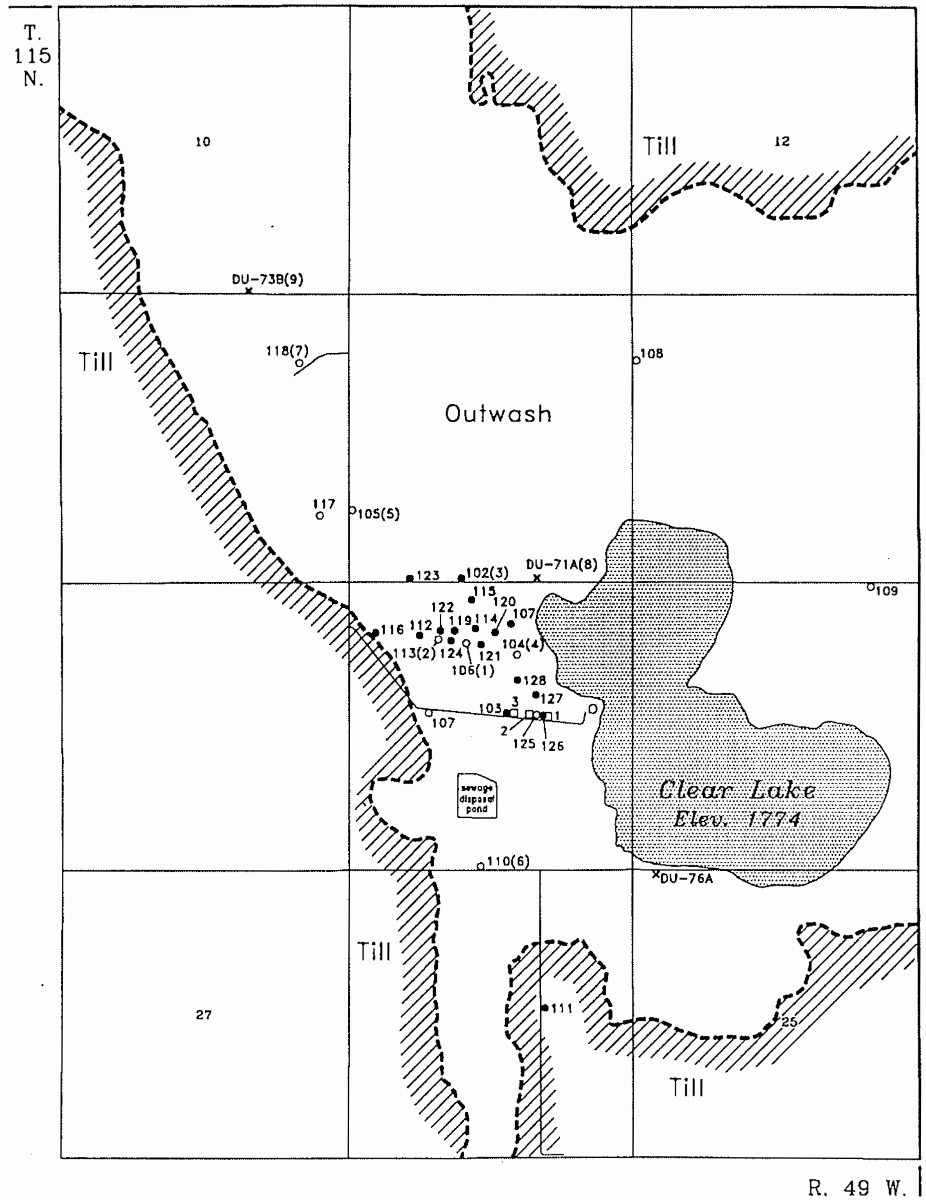


Figure 2. Location of test holes, city wells, observation wells, and water samples.

•115 Test hole. Number is the last 3 digits of the well identifier (CO-82-___) in the South Dakota Geological Survey files.

o102(3) Test hole with observation well installed and water sample taken. First number is the last 3 digits of well identifier (CO-82-___) in the South Dakota Geological Survey files. Number in parentheses () refers to water sample number in table 2.

DU-71A(8) × Water Rights Program observation well. Letters and numbers preceding parentheses (), if parentheses are present, are the well identifier. Number in parentheses () refers to water sample number in table 2.

3 □ City well. Number refers to the city well identification.

Approximate boundary between the till and outwash.

0 ——— 1 Mile

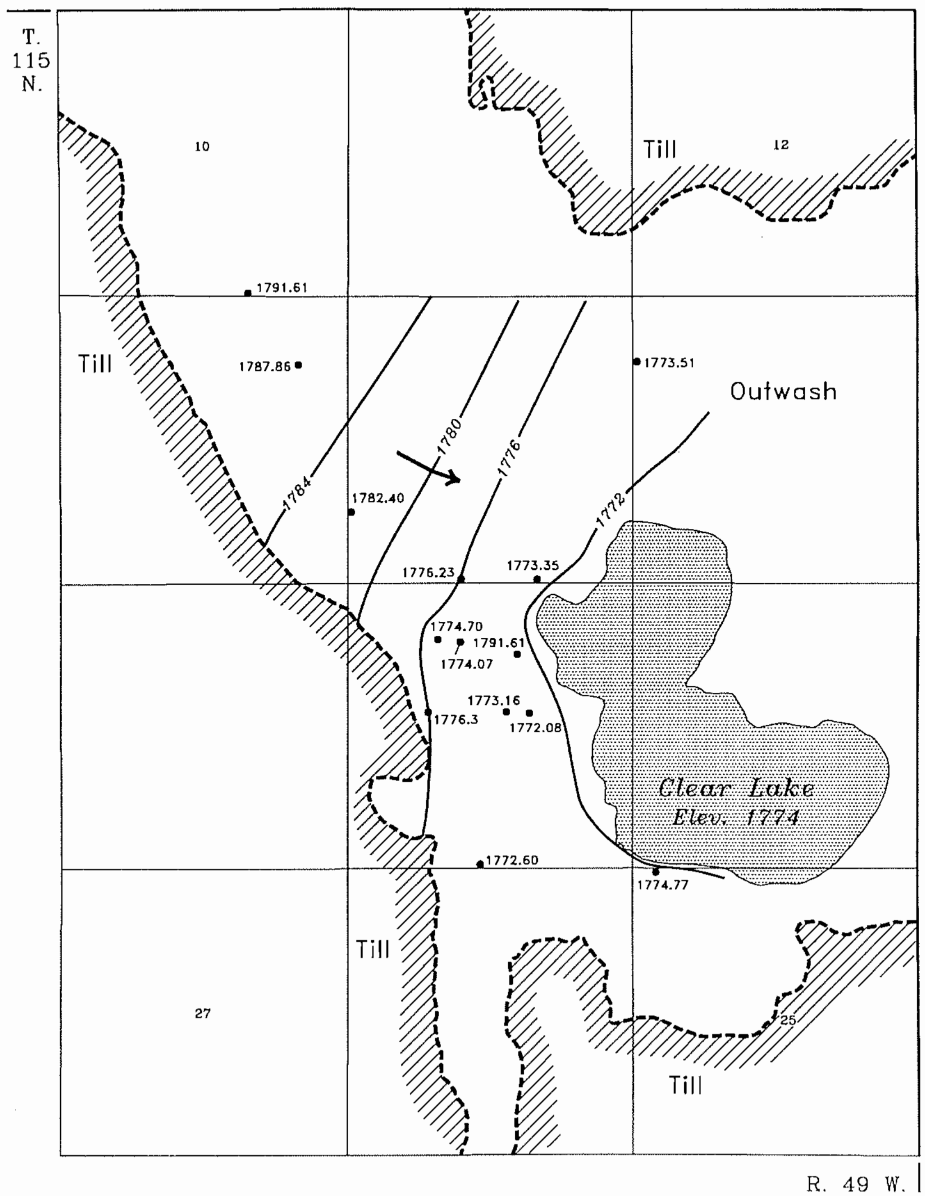


Figure 3. Water table elevations on August 12, 1982, and direction of ground water flow.

1773.35 • Water table elevations, in feet above mean sea level, as measured at observation well.

1772 — Contour line connecting points of equal elevation on the water table.

→ Approximate direction of ground water movement.

Approximate boundary between the till and outwash.

0 — 1 Mile

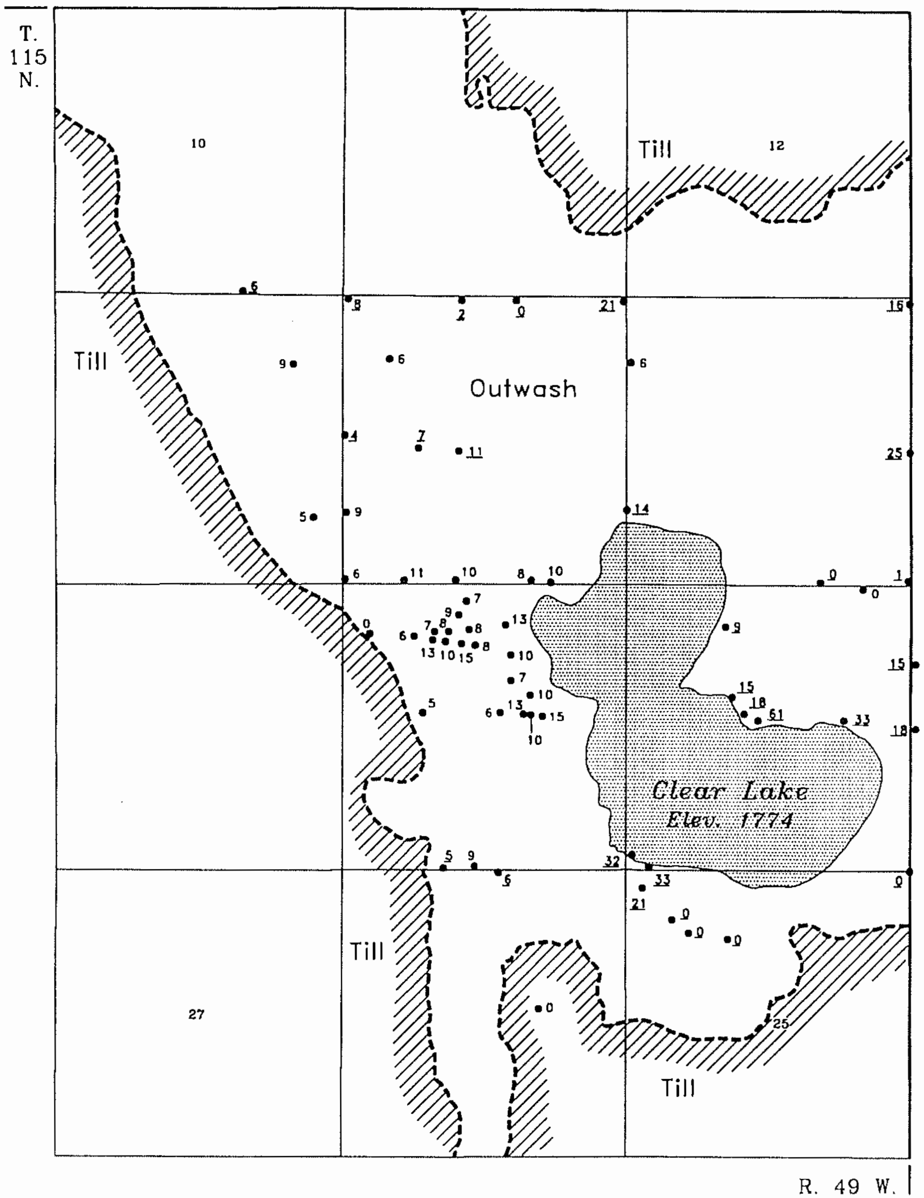


Figure 4. Map showing saturated thickness of the surface outwash.

•10 Saturated thickness, in feet, from 1982 study.

•7 Saturated thickness, in feet, from 1976 study.

Approximate boundary between the till and outwash.

0 1 Mile

Table 1. Sodium, chloride, and total dissolved solids values in City Wells 1 and 2 from 1966 through 1981

	CITY WELL 1				CITY WELL 2					
	1968	1972	1978	1981	1966	1968	1971	1975	1978	1981
Sodium	17	15	24	20	13	52	22	14	238	312
Chloride	6	6	82	42	70	315	50	27	815	928
Total dissolved solids	--	693	836	601	532	1523	688	675	2090	2229

Source of data: South Dakota Department of Environment and Natural Resources files

Table 2. Chemical analyses of water samples collected in the Clear Lake area

Water sample identi-fication	Well identifier	Parameter[1] with concentration in parts per million											Conduc-tivity[2]
		Ca	Na	Mg	Fe	Mn	Cl	F	N	SO_4	$CaCO_3$	TDS	
Standards	---	---	---	---	0.3[3]	0.05[3]	250[3]	4.0[4]	10.0[4]	250[3]	---	500[3]	---
B	City Well 1	123	20	43.0	<0.02	0.08	42.5	0.19	1.9	149	484	601	936
C	City Well 2	290	312	93.0	<0.02	<0.02	928	0.16	3.9	152	1107	2299	3536
1	106	126	16	42.2	0.11	0.52	15	0.24	0.1	242	488	648	917
2	113	95	14	34.8	0.05	0.03	9	0.26	1.4	175	380	482	755
3	102	98	14	32.3	0.06	0.33	7	0.28	0.4	163	377	500	725
4	104	89	12	30.6	0.05	0.61	21	0.30	0.1	134	348	502	669
5	105	109	34	24.8	0.06	0.05	14	0.29	8.8	180	374	624	769
6	110	200	370	56.6	<0.01	0.08	670	0.38	0.2	225	733	1480	2310
7	118	119	16	42.4	0.03	0.37	7	0.22	0.1	200	472	604	814
8	DU-71A	86	10	28.1	0.04	0.01	6	0.23	6.3	85	330	458	602
9	DU-73B	130	12	42.6	0.70	0.57	3	0.20	0.1	239	500	710	877

[1]**Ca** - calcium; **Na** - sodium; **Mg** - magnesium; **Fe** - iron; **Mn** - manganese; **Cl** - chloride; **F** - fluoride; **N** - nitrate + nitrate (both as N); **SO_4** - sulfate; **$CaCO_3$** - Hardness as $CaCO_3$; **TDS** - total dissolved solids
[2]Conductivity is presented in micromhos per centimeter.
[3]U.S. Environmental Protection Agency "Drinking Water Regulations and Health Advisories": November 1994 (Secondary maximum contaminant levels. Recommended limits.)
[4]U.S. Environmental Protection Agency "Drinking Water Regulations and Health Advisories": November 1994 (Maximum contaminant level. Enforceable limits.)
All samples were collected in August 1982 except for samples A and B which were collected in December 1981.